SECTION 9 – TOTAL ORGANIC CARBON (TOC)

SUMMARY

The Rio de las Vacas, Clear Creek, and Rito Peñas Negras watersheds are sub-basins within the Jemez River Basin, located in north central New Mexico. As a result of the 1998-1999 SWQB/NMED monitoring effort in the Jemez River Basin, several exceedances of New Mexico water quality standards for total organic carbon (TOC) were documented on the Rio de las Vacas, Clear Creek, and the Rito Peñas Negras. Two stations were located on Rito Peñas Negras, three on Rio de las Vacas, and one on Clear Creek. These stations were used to evaluate the impact of each watershed and to establish background conditions.

Figures 5.G.1 and 5.G.2 in Section 5 show the land use/cover and land ownership percentages for the segment of the Rio de las Vacas listed in the 2000-2002 §303(d) list for this constituent (the Rio de las Vacas from the confluence with the Rio Cebolla to the Rito de las Palomas). Figures 5.H.1 and 5.H.2, also in Section 5, and 5.I.1 and 5.I.2 show the land use/cover and land ownership percentages for the segments of Clear Creek (Clear Creek from its confluence with the Rio de las Vacas to San Gregorio Reservoir), and Rito Peñas Negras (Rito Peñas Negras from its mouth on the Rio de las Vacas to the headwaters), respectively. Detailed descriptions of the preceding segments can be found in subsections G, H, and I, of Section 5. This section of this Total Maximum Daily Load (TMDL) document addresses TOC in the impacted 11.6-mile, 14-mile, and 4.6-mile stretches of the Rio de las Vacas, Clear Creek and Rito Peñas Negras, respectively.

ENDPOINT IDENTIFICATION

Target Loading Capacity

Overall, the target values for this TMDL will be determined based on 1) the presence of numeric criteria, 2) the degree of experience in applying the indicator, and 3) the ability to easily monitor and produce quantifiable and reproducible results. For this TMDL document target values for TOC are based on numeric criteria. This TMDL is consistent with the State's antidegradation policy.

Organic matter content in streamflow is typically measured as total organic carbon and dissolved organic carbon, which consists of thousands of components including macroscopic particles, colloids, dissolved micromolecules, and specific compounds. Total Organic Carbon (TOC) measurements are affected by the climate and the amount of vegetation within, or contributing to, detritus in the waterbody. For this section target values for total organic carbon are based on numeric criteria. The affect of excess TOC in a waterbody exhibits the same characteristics of turbidity, showing decreased light penetration and depletion of oxygen.

Total Organic Carbon (TOC)

The water quality standards specify that "total organic carbon shall not exceed 7 mg/l" for any water designated by the New Mexico Water Quality Control Commission as a high quality coldwater fishery (HQCWF). These three segments, along with most streams in the Jemez River

Basin, list HQCWF as a use not fully supported. Each of these three segments fall under standard Segment 20.6.4.108 (formerly 2106), which includes:

> The Jemez River and all its tributaries above State Highway 4 near the town of Jemez Springs, and the Guadalupe River and all its tributaries.

Flow

Total organic carbon movement in a stream varies as a function of flow. As flow decreases the concentrations of some pollutants increase. TMDLs are calculated for each reach at a specific flow; in this case the target flow was critical low flow.

When available, USGS gages are used to estimate flow. Where gages are absent or poorly located along a reach, either actual flow (measured as water quality samples are taken) is used as target flows or geomorphologic sectional information is taken to model the flows. In these cases there were no USGS gages for Rio de las Vacas, Clear Creek, or Rito Peñas Negras. The presence of TOC can vary in a stream as a function of flow. As flow decreases, concentrations of TOC can increase. Thus, a TMDL is calculated for each reach at a particular flow.

The flow value used to calculate the TMDL for TOC on all three waterbodies was obtained using the 4-day, 3-year low flow frequency 4Q3 regression model.

The 4Q3 is the annual lowest 4 consecutive day period discharge that will not fall below that discharge at least every 3 years (USGS, 2001). Low flow was chosen as the critical flow because the exceedances of the TOC standard occurred only during low flow periods (July and November 1998).

It is often necessary to calculate a critical flow for a portion of a watershed where there is no flow gage as in these three waterbodies. This can be accomplished by applying one of two formulas developed by the USGS. The first formula (Waltemeyer, 1987) is recommended when the ratio between the two watershed areas is between 0.5 and 1.5. The other formula, to be used when the watershed ratio is outside this range, is a regression formula also developed by the USGS (Borland, 1970). Procedures for obtaining the low flow value for each stream are described below:

<u>RIO DE LAS VACAS:</u>

1) The nearest gage to the point of interest is the Rio Guadalupe at Box Canyon (08323000). The drainage area above this gage (A_g) is 268 mi^2. The watershed above the area of interest (A_u) is 123 mi^2. The ratio of watershed size (123/268) is 0.46. Because this ratio value is less than 0.5, the guidelines recommended by USGS are applied and the formula for calculating 7Q2 in step 2 is used.

2) $$Q_{7/2} = 1.36x10^{-4} \times (A_u)^{.566} \times (P_a)^{3.22}$$

Where,

A_u = Watershed area of interest, in square miles

P_a = Mean precipitation (October thru April), in inches

Thus,

$$Q_{7/2} = 1.36x10^{-4} \times (123)^{.566} \times (11)^{3.22}$$

$$Q_{7/2} = 4.7 \text{ cfs}$$

3) The plot of the 1-day, 3-day, and 7-day low flow events at this gage as well as the model verification is described in the TMDL document written for Redondo Creek (SWQB/NMED, 1999). From the reference graph, the $Q_{4/3}$ low flow is 5.5 cfs. The $Q_{7/2}$ is 6.3 cfs. The ratio of $Q_{4/3}$ /$Q_{7/2}$ (R) is 0.87.

4) Multiplying the $Q_{7/2}$ value from step 2 ($Q_{7/2}$ = 4.7 cfs) and the ratio from step 3 (R = 0.87), the estimated 4Q3 value is:

$$Q_{4/3(est)} = R \times Q_{7/2}$$
$$Q_{4/3(est)} = 0.87 \times 4.7 \text{ cfs}$$
$$\mathbf{Q_{4/3(est)} = 4.1 \text{ cfs} = 2.6 \text{ MGD}}$$

CLEAR CREEK:

1) The nearest gage to the point of interest is the Rio Guadalupe at Box Canyon (08323000). The drainage area above this gage (A_g) is 268 mi^2. The watershed above the area of interest (A_u) is 10.6 mi^2. The ratio of watershed size (10.6/268) is 0.04. Because this ratio value is less than 0.5, the guidelines recommended by USGS are applied and the formula for calculating 7Q2 in step 2 is used.

2) $$Q_{7/2} = 1.36 \times 10^{-4} \times (A_u)^{.566} \times (P_a)^{3.22}$$

Where,
A_u = Watershed area of interest, in square miles
P_a = Mean precipitation (October thru April), in inches

Thus,

$$Q_{7/2} = 1.36 \times 10^{-4} \times (10.6)^{.566} \times (11)^{3.22}$$
$$Q_{7/2} = 1.2 \text{ cfs}$$

3) The plot of the 1-day, 3-day, and 7-day low flow events at this gage as well as the model verification is described in the TMDL document written for Redondo Creek (SWQB/NMED, 1999). From the reference graph, the $Q_{4/3}$ low flow is 5.5 cfs. The $Q_{7/2}$ is 6.3 cfs. The ratio of $Q_{4/3}$ /$Q_{7/2}$ (R) is 0.87.

4) Multiplying the $Q_{7/2}$ value from step 2 ($Q_{7/2}$ = 1.2 cfs) and the ratio from step 3 (R = 0.87), the estimated 4Q3 value is:

$$Q_{4/3(est)} = R \times Q_{7/2}$$
$$Q_{4/3(est)} = 0.87 \times 1.2 \text{ cfs}$$
$$\mathbf{Q_{4/3(est)} = 1.0 \text{ cfs} = 0.65 \text{ MGD}}$$

RITO PEÑAS NEGRAS:

1) The nearest gage to the point of interest is the Rio Guadalupe at Box Canyon (08323000). The drainage area above this gage (A_g) is 268 mi^2. The watershed above the area of interest (A_u) is 17.2 mi^2. The ratio of watershed size (17.2/268) is 0.06. Because this ratio value is less than 0.5, the guidelines recommended by USGS are applied and the formula for calculating 7Q2 in step 2 is used.

2) $$Q_{7/2} = 1.36x10^{-4} \times (A_u)^{.566} \times (P_a)^{3.22}$$

Where,
A_u = Watershed area of interest, in square miles
P_a = Mean precipitation (October thru April), in inches

Thus,

$$Q_{7/2} = 1.36x10^{-4} \times (17.2)^{.566} \times (11)^{3.22}$$
$$Q_{7/2} = 1.5 \text{ cfs}$$

3) The plot of the 1-day, 3-day, and 7-day low flow events at this gage as well as the model verification is described in the TMDL document written for Redondo Creek (SWQB/NMED, 1999). From the reference graph, the $Q_{4/3}$ low flow is 5.5 cfs. The $Q_{7/2}$ is 6.3 cfs. The ratio of $Q_{4/3}$ /$Q_{7/2}$ (R) is 0.87.

4) Multiplying the $Q_{7/2}$ value from step 2 ($Q_{7/2}$ = 1.5 cfs) and the ratio from step 3 (R = 0.87), the estimated 4Q3 value is:

$$Q_{4/3(est)} = R \times Q_{7/2}$$
$$Q_{4/3(est)} = 0.87 \times 1.5 \text{ cfs}$$
$$\mathbf{Q_{4/3(est)} = 1.3 \text{ cfs} = 0.84 \text{ MGD}}$$

It is important to remember that the TMDL is a planning tool to be used to achieve water quality standards. Under current water quality standards, since flows vary throughout the year in these systems, the target load will vary based on the changing flow. Management of the load to improve stream water quality should be a goal to be attained; meeting the calculated target load may be a difficult objective.

Calculations

A target load for TOC is calculated based on a flow, the current water quality standards, and a unit-less conversion factor, 8.34, that is a used to convert mg/L units to lb/day (see Appendix A for conversion factor derivation). The target loads (TMDLs) predicted to attain standards were calculated using Equation 1 and are shown in Table 9-1.

Equation 1.

Critical Flow (MGD) x Standard (mg/L) x 8.34 (conversion factor) = Target Loading Capacity

Table 9-1: Calculation of Target Loads

Location	*Flow (MGD)	Standard for Metals (Chronic Aluminum) (mg/L)	**Conversion Factor	Target Load Capacity (lb/day)
Rio de las Vacas	2.6	7.0	8.34	151.8
Clear Creek	0.65	7.0	8.34	37.9
Rito Peñas Negras	0.84	7.0	8.34	49.0

* Flow is the 4Q3 value calculated on the previous pages.
**Conversion Factor used to convert mg/L to lb/day (See Appendix A).

The measured loads were similarly calculated. The flows used were derived from the critical low flow, 4Q3 determination. The geometric mean of the data that exceeded the standards from the data collected at each site for TOC was substituted for the standard in Equation 1. Graphical results for the TOC data collected on each reach are displayed in Figures 9-1 through 9-3 located at the end of this section. The same conversion factor of 8.34 was used to convert mg/L to lb/day. Results are presented in Table 9-2.

Table 9-2: Calculation of Measured Loads

Location	* Flow (MGD)	✧Field Measurements Total Organic Carbon (mg/L)	**Conversion Factor	Measured Load (lb/day)
Rio de las Vacas	2.6	7.86	8.34	170.4
Clear Creek	0.65	9.9	8.34	53.7
Rito Peñas Negras	0.84	9.1	8.34	63.8

* Flow is the 4Q3 value calculated on the previous pages.
✧ Field Measurements are the geometric mean of the values that exceeded the standard (Table 9-6).
**Conversion Factor used to convert mg/L to lb/day (See Appendix A).

Background loads were not possible to calculate in these watersheds. It is assumed that a major portion of the load allocation is made up of natural background loads. This will be a future determination based on applicability of suitable reference reaches.

Waste Load Allocations and Load Allocations

•*Waste Load Allocation*
There are no point source contributions associated with these TMDLs. The waste load allocations are zero.

•*Load Allocation*
In order to calculate the Load Allocations (LA) the waste load allocations and margins of safety (MOS) were subtracted from the target capacities (TMDL) following Equation 2.

Equation 2. $WLA + LA + MOS = TMDL$

Results using a Margin of Safety (MOS) of 15% (explained further in this section) are presented in Table 9-3 as follows:

Table 9-3: Calculation of TMDL for TOC

Location	WLA (lb/day)	LA (lb/day)	MOS (15%) (lb/day)	TMDL (lb/day)
Rio de las Vacas	0	129.0	22.8	151.8
Clear Creek	0	31.9	6.0	37.9
Rito Peñas Negras	0	41.6	7.4	49.0

The load reductions that would be necessary to meet the target loads were calculated to be the difference between the loads allocation (Table 9-3) and the measured loads (Table 9-2), and are shown in Table 9-4. For example, on the Rio de las Vacas, achieving the target load of 151.8 lb/day would require a load reduction of 18.6 lb/day, or an 11% load reduction.

Table 9-4: Calculation of Load Reductions (lb/day)

Location	Load Allocation (lb/day)	Measured Load (lb/day)	Load Reduction (lb/day)
Rio de las Vacas	129.0	170.4	41.4
Clear Creek	31.9	53.7	21.8
Rito Peñas Negras	41.6	63.8	22.2

Identification and Description of Pollutant Source(s)

Pollutant sources that could contribute to each of these stream segments are listed in Table 9-5 on the following page.

Table 9-5: Pollutant Source Summary

Pollutant Sources	Magnitude (WLA+LA+MOS) (mg/L)	Location	Potential Sources (apply to three segments) (% from each)
Point: None	0	--------	0%
Nonpoint:	151.8	Rio de las Vacas	100%
Total Organic Carbon (TOC)	37.9	Clear Creek	Natural And Unknown
	75.9	Rito Peñas Negras	

LINK BETWEEN WATER QUALITY AND POLLUTANT SOURCES

Where available data are incomplete or where the level of uncertainty in the characterization of sources is large, the recommended approach to TMDL assignments requires the development of allocations based on estimates utilizing the best available information. Data that were collected and used for the calculations of the existing conditions for the stream segments, with respect to total organic carbon, are included in Table 9-6.

SWQB fieldwork includes an assessment of the potential sources of impairment (SWQB/NMED, 1999). The Pollutant Source(s) Documentation Protocol, shown as Appendix B, provides an approach for a visual analysis of the source along an impaired reach. Although this procedure is subjective, SWQB feels that it provides the best available information for the identification of potential sources of impairment in this watershed. Table 9-5, Pollutant Source Summary, identifies and quantifies potential sources of nonpoint source impairments along each reach as determined by field reconnaissance and assessment. A further explanation of the sources follows.

In general, the Rio de las Vacas is a fairly broad and somewhat shallow stream, with very little canopy cover, despite healthy riparian areas (as shown in the photo below). The criterion for TOC was exceeded at all three stations located on this stream during the Fall sampling effort. These exceedances were probably associated with decomposition of deciduous vegetation (SWQB/NMED, 2001).

Photo 22. Rio de las Vacas at Porter – upstream of the confluence with Rio Cebolla

Pollutant Sources on Rito Peñas Negras

The Rito Peñas Negras, at Station 20, exceeded the TOC criterion as well during the Fall sampling run. Similarly to the Vacas, these results were probably due to decomposition of deciduous vegetation.

Photo 23. Rito Peñas Negras

The exception, however, was Clear Creek (Station 22) where TOC levels exceeded the criterion during all sampling runs. For five TOC samples collected during the Summer, the average concentration was 9.6 mg/L. Six were collected during the fall and the average concentration was 10.5 mg/L; these values are compared to the 7.0 mg/L criterion, applicable to the designated use of a high quality coldwater fishery.

San Gregorio Reservoir, just upstream of this station, is a small impoundment in the San Pedro Parks Wilderness Area. Springs, wetlands, and a great deal of decomposing vegetation surround the reservoir. This area is probably attributable to TOC exceedances at Station 22. No impacts attributable to elevated TOC were detected at Station 22 during the survey (SWQB/NMED, 2001).

MARGIN OF SAFETY (MOS)

TMDLs should reflect a margin of safety based on the uncertainty or variability in the data, the point and nonpoint source load estimates, and the modeling analysis. For this TMDL, there will be no margin of safety for point sources, since there are none. However, for the nonpoint sources the margin of safety is estimated to be an addition of 15**%** for TOC to these TMDLs, excluding the background. This margin of safety incorporates several factors:

- *Errors in calculating NPS loads*

  A level of uncertainty exists in sampling nonpoint sources of pollution. Accordingly, a conservative margin of safety for total organic carbon increases the TMDL by 10%.

- *Errors in calculating flow*

  Flow estimates were based on the estimation of the 4Q3 for ungaged streams and compared to actual flows and cross sectional information taken in the field. Techniques for measuring the flow on these three segments have a ($\pm$)5% precision. Accordingly, a conservative margin of safety increase the TMDL by 5%.

CONSIDERATION OF SEASONAL VARIATION

Data used in the calculation of this TMDL were collected during spring, summer, and fall in order to ensure coverage of any potential seasonal variation in the system. Critical condition is set to the lowest critical flows for total organic carbon. TOC movement in a stream varies as a function of flow. As flow decreases, the concentrations of some pollutants increase. In these cases, the target flows were critical low flows. Only data where exceedances were measured were used in the calculation of the geometric mean of the measured loads and are found in Table 9-6 on the following page.

FUTURE GROWTH

Estimations of future growth are not anticipated to lead to a significant increase for total organic carbon that cannot be controlled with best management practice implementation in this watershed.

TABLE 9-6: TOC RESULTS DURING 1998-1999 SAMPLING EFFORT

			DATA	
Stream Segment	**Station #**	**Refer to Figure**	**Date of Sample**	**TOC Exceedance (mg/L)**
Rio de las Vacas	18	9-1	11/2/1998	7.42
			11/3/1998	7.54
			11/4/1998	7.23
Rio de las Vacas	19	9-1	7/13/1998	7.28
			11/2/1998	7.87
			11/3/1998	7.3
			11/4/1998	7.67
Rio de las Vacas	23	9-1	7/13/1998	8.55
			11/2/1998	10.1
			11/3/1998	7.96
			11/4/1998	7.92
	Geometric Mean of the Exceedances =			7.86

			DATA	
Stream Segment	**Station #**	**Refer to Figure**	**Date of Sample**	**TOC Exceedance (mg/L)**
Clear Creek	22	9-2	7/13/1998	11.4
			7/14/1998	8.7
			7/15/1998	9.29
			7/16/1998	8.91
			11/2/1998	10.9
			11/3/1998	10.3
			11/4/1998	10.4
	Geometric Mean of the Exceedances =			9.94

			DATA	
Stream Segment	**Station #**	**Refer to Figure**	**Date of Sample**	**TOC Exceedance (mg/L)**
Rito Penas Negras	20	9-3	11/2/1998	7.93
			11/3/1998	9.77
			11/4/1998	9.65
	Geometric Mean of the Exceedances =			9.08

* TOC exceedances are based on a standard of 7 mg/L

FIGURES 9-1 THROUGH 9-3
1998-1999 SWQB/NMED SAMPLING SEASON RESULTS
(TOC EXCEEDANCES)